THE STABILITY OF LIQUID AND SOLID BASALT, SULFUR, AND SULFUR DIOXIDE IN IO'S SUBSURFACE.

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Volcanism on Io involves primarily three substances– molten silicates (probably basalt), molten sulfur, and sulfur dioxide (the chief volcanic volatile on Io). Other substances, such as Na_2S_5 and Na_2SO_4, also may be involved in Ionian volcanism. SO_2 is a domi-nant component of Io's torus and neutral atmosphere, and SO_2 is a widespread conden-sate on Io. Io's explosive volcanism further implies that SO_2 exists at some depth, where it superheats by interaction with sulfur and sili-cate magmas. We have calculated the stability of solid and liquid basalt, sulfur, and sulfur dioxide in Io's subsurface for conditions appropriate to a range of possible heat flow and temperature-dependent thermal conductivi-ties for basalt (Fig. 1) and solid sulfur (Fig. 2). In this first set of calculations we have ig-nored dynamic effects such as latent heat and thermal perturbations expected from ground-fluid circulation and magma transport. Our thermal models show that liquid SO_2 is stable at shallow depths of tens to several hundred meters depending on the local heat flow and the composition and thermal conductivity of surface rocks. Molten sulfur is stable at about twice the depth of liquid SO_2, whereas basalt generally is solid to a depth of 1-10 km except near volcanic vents, intrusions, and in lava flows. Sulfur's unique rheological char-acteristics imply that under static conditions molten sulfur in the subsurface effectively should have two "melting" points separated in temperature (and depth) by very stiff polymerized liquid sulfur.

Figures 1 and 2, taken at face value, imply that sulfur and sulfur dioxide "aquifers" occur at very shallow levels in Io's crust, even where heat flow is much less than the global average. Seepage of liquid sulfur dioxide (with boiling as it is vented) may account for erosional terrains near Io's South Pole.

It is puzzling that areas of high or modest heat flow do not have hundreds of small volcanic vents (at least at Voyager resolution). It may be that in these areas the ground fluids are so shallow that eruptions tend to have very small volumes and produce vents and edifices of a scale too small to be seen at Voyager resolutions. This situation could produce small sulfur hornitos, cinder conelets, and small flows comparable to those of terrestrial basaltic and carbonatite lava lakes and the small, closely spaced geysers at Yellowstone National Park.

There are good reasons not to take these calculations at face value for some regions. Huge massifs protrude through the main, plains-forming deposits on Io and attain elevations of many kilometers. Clearly these mountains are supported by a strong lithosphere that must be more than a few kilometers thick. Thermal infrared emissions indicate that Io's heat flow is extraordinarily variable, and some regions have rather shallow conductive geotherms. Furthermore, our models do not take into account what we expect to be large thermal perturbations due to thermal convection of ground fluids.

Our next step is to consider subsurface con-vective transfer of mass and energy and fluid-volatile interactions responsible for explosive eruptions on Io.

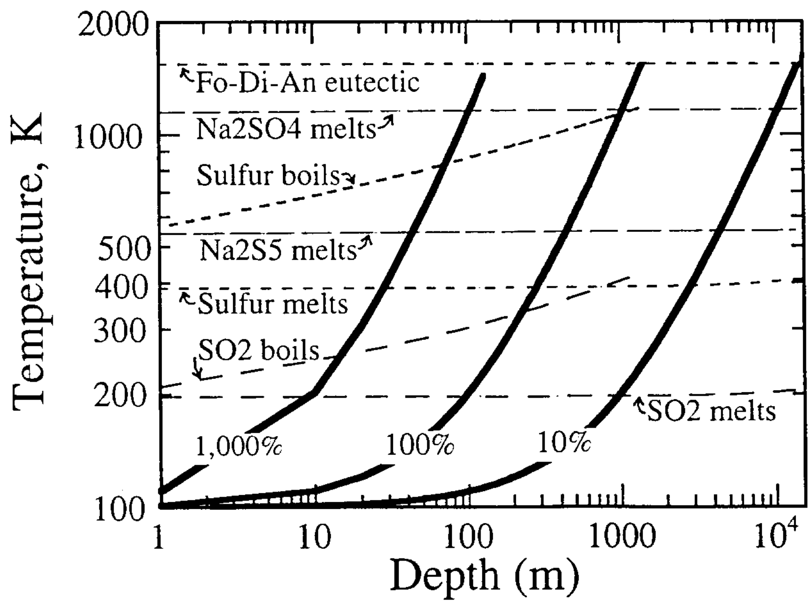

Figure 1. Geotherms and phase transitions in a basaltic crust. The bold curves are the geotherms calculated for conductive heat flows equal to 10%, 100%, and 1000% of Io's global average heat flux (including that emitted from hot spots and lava flows). The lower value of heat flow might correspond to colder regions in Io's crust, whereas the higher values might correspond to areas near hot spots. The basalt solidus is approximated as the eutectic temperature in the dry system forsterite-diopside-anorthite.

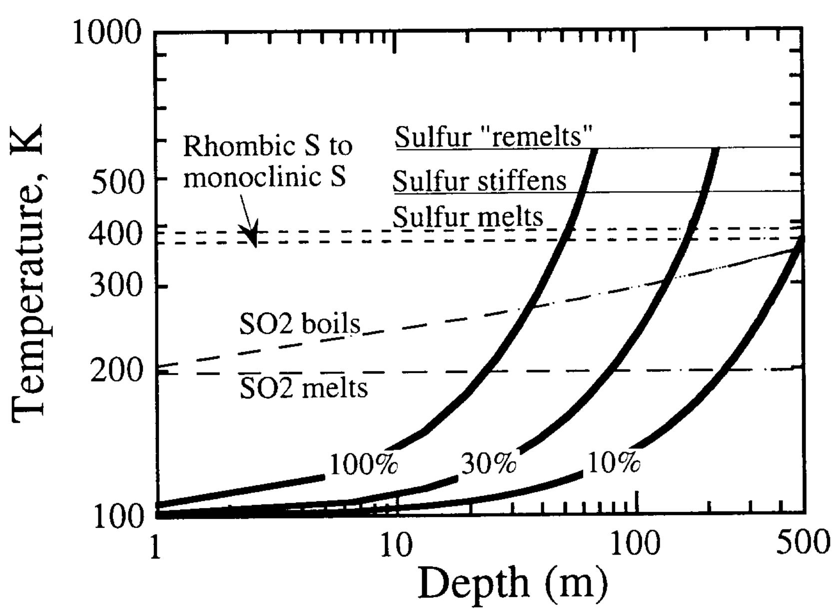

Figure 2. Geotherms and phase transitions in a sulfur crust. The bold curves are the geotherms calculated for conductive heat flows equal to 10%, 30%, and 100% of Io's global average heat flux (including that emitted from hot spots and lava flows).